

APPENDIX I

RISK, COMPETITIVENESS & CONSERVATION DATA SUMMARY AND SOCIAL BENEFITS/COSTS ASSESSMENT: LITHOGRAPHY CTSA

Earlier sections of the lithography CTSA evaluated the risk and performance of the baseline blanket wash as well as the alternatives. These data provide the basis for comparing the benefits and costs of using the alternative blanket washes instead of the baseline. Relevant data include: worker health risks, public health risks, flammability risks, ecological risks, energy and natural resource use, volatile organic compound (VOC) content, and labor, materials, and product costs. Each is discussed in turn below.

Worker Health Risks

The majority of substitute formulations, as well as the baseline, present some concern for dermal exposure, driven primarily by high exposure levels. The dermal exposure estimates provide an upper-bound estimate which no worker is expected to exceed because the exposure assessment assumes that no gloves or barrier creams are used by workers when cleaning a blanket. Worker inhalation risks are very low for nearly all of the blanket wash products due to low or negligible exposure levels. Only one of the substitute formulations (Blanket Wash 3) triggered inhalation concerns. The components of all other substitute products present low or no concern. The baseline presents low inhalation concern. Table I-1 presents a summary of worker risks beginning with the baseline product, VM&P Naphtha. The risk assessment assumed that components of concern present a greater risk than components of low to moderate concern, and components of low to moderate present a greater risk than components of low concern, and so on (no/low concern < low to moderate concern < concern).

TABLE I-1: SUMMARY OF RISK CONCLUSIONS OF SUBSTITUTE AND BASELINE BLANKET WASH CLEANERS			
Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
Baseline (28)	Hydrocarbons, petroleum distillates	concern	no/low concern
1	No individual chemicals of concern identified	no/low concern ^a	no/low concern ^a
3	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, aromatic	concern	concern
	Hydrocarbons, aromatic	concern	no/low concern
4	Terpenes	concern	no/low concern
	Ethoxylated nonylphenols	no/low concern	no/low concern ^b
5	Hydrocarbons, aromatic	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
	Propylene glycol ethers	concern	no/low concern
6	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^b
	Fatty acid derivatives	no/low concern ^b	no/low concern ^b
	Alkyl benzene sulfonates	no/low concern ^b	no/low concern ^b

APPENDIX I

TABLE I-1: SUMMARY OF RISK CONCLUSIONS OF SUBSTITUTE AND BASELINE BLANKET WASH CLEANERS			
Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
7	Terpenes	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
8	Propylene glycol ethers	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^b
9	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
10	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
11	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^b
	Alkyl benzene sulfonates	no/low concern ^a	no/low concern ^b
12	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a
14	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
	Propylene glycol ethers	no/low concern ^a	no/low concern ^b
16	Terpenes	concern	no/low concern
17	Glycols	no/low concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
	Alkali/salts	no/low concern	no/low concern ^b
	Fatty acid derivatives	possible concern	no/low concern ^b
18	Hydrocarbons, petroleum distillates	concern	no/low concern
	Dibasic esters	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern ^a	no/low concern ^a
	Esters/lactones	no/low concern ^a	no/low concern ^a
19	Propylene glycol ethers	no/low concern ^a	no/low concern ^a
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
20	Hydrocarbons, petroleum distillates	concern	no/low concern
	Alkyl benzene sulfonates	no/low concern ^a	no/low concern ^a
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^a
21	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Fatty acid derivatives	no/low concern ^a	no/low concern ^a

TABLE I-1: SUMMARY OF RISK CONCLUSIONS OF SUBSTITUTE AND BASELINE BLANKET WASH CLEANERS			
Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
22	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^a
	Fatty acid derivatives	no/low concern ^a	no/low concern ^a
23	Terpenes	possible concern	no/low concern
	Nitrogen heterocyclics	possible concern	no/low concern
24	Alkyl benzene sulfonates	concern	no/low concern ^b
	Terpenes	concern	no/low concern
	Ethylene glycol ethers	possible concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
25	Terpenes	concern	no/low concern
	Esters/lactones	possible concern	no/low concern
26	Esters/lactones	concern	no/low concern ^b
	Esters/lactones	no/low concern	no/low concern ^b
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
27	Terpenes	concern	no/low concern
29	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
30	Hydrocarbons, aromatic	concern	no/low concern
	Propylene glycol ethers	no/low concern ^a	no/low concern ^a
31	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a
32	Hydrocarbons, petroleum distillates	low to moderate concern ^a	low to moderate concern ^a
33	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	no/low concern	no/low concern
34	Terpenes	concern	no/low concern
	Alkoxylated alcohols	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a
35	Hydrocarbons, aromatic	concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a

TABLE I-1: SUMMARY OF RISK CONCLUSIONS OF SUBSTITUTE AND BASELINE BLANKET WASH CLEANERS			
Formula Number	Chemicals Identified as a Concern in the Risk Assessment	Worker Health Risk	
		Dermal	Inhalation
36	Hydrocarbons, petroleum distillates	concern	no/low concern
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^b
	Propylene glycol ethers	no/low concern	no/low concern
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
37	Hydrocarbons, aromatic	possible concern	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a
	Hydrocarbons, petroleum distillates	low to moderate concern ^a	no/low concern ^a
38	Fatty acid derivatives	no/low concern ^a	no/low concern ^b
	Alkoxylated alcohols	no/low concern ^a	no/low concern
	Hydrocarbons, petroleum distillates	low to moderate concern	no/low concern ^a
39	Hydrocarbons, petroleum distillates	concern	no/low concern
	Propylene glycol ethers	concern	no/low concern
	Alkanolamines	concern	no/low concern ^b
	Ethylene glycol ethers	possible concerns	no/low concern
40	Hydrocarbons, petroleum distillates	concern	no/low concern
	Ethoxylated nonylphenol	no/low concern	no/low concern ^b
	Hydrocarbons, aromatic	moderate concern ^a	no/low concern ^b
	Fatty acid derivatives	no/low concern ^a	no/low concern ^b

a) Risks for these chemicals in this product could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis of potential hazard.

b) Risks for these chemicals in this product could not be quantified; therefore, the level of concern for this chemical is based upon a low risk call based on estimates of no or extremely low exposure.

Public Health Risks

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Individuals in the general public that are exposed to blanket wash chemicals are potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion due to use of blanket washes. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.¹ Flammable liquids are defined by OSHA as having a flash point less than 141°F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140°F or less. Table I-2 presents the flash points of the baseline as well as the alternative blanket washes. Flash points were developed as part of the performance demonstration.

TABLE I-2: RELATIVE FLAMMABILITY RISK OF SUBSTITUTE AND BASELINE BLANKET WASHES			
Blanket Wash	Flash Point (°F)	Blanket Wash	Flash Point (°F)
<i>Baseline (28)</i>	50	22	157+
1	230+	23	140
3	114	24	100
4	114	25	220+
5	139	26	230+
6	152	27	145
7	165	29	230+
8	115	30	100+
9	230+	31	105
10	230+	32	220
11	150	33	105
12	125	34	138
14	230+	35	105
16	145	36	175
17	220+	37	82
18	150	38	230+
19	230+	39	155
20	170	40	155
21	115		

¹ Flash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

Ecological Risk

The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; in the analysis for this CTSA, only the risks to aquatic species were considered. Evaluation of aquatic risks involved comparing a predicted ambient water concentration to a "concern concentration" for chronic exposures to aquatic species using a hypothetical receiving stream (a relatively small stream at low flow conditions). The concern concentration is expressed in mg/L water. Exposure concentrations below the concern concentration are assumed to present low risk to aquatic species. Exposures that exceed the concern concentration indicate a potential for adverse impact on aquatic species. The following formulations were found to pose a risk to aquatic species: Blanket Washes 3, 5, 6, 8, 11, 18, and 20. All the chemicals of concern are amine salts of an alkybenzene sulfonate. Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Use

The life cycle of any product begins with the extraction of raw materials from the environment, and continues through the manufacture, transportation, use, recycle, and disposal of the product. Decisions at each stage of a product's life will impact its energy and natural resource demand. A previous section of the CTSA presented a discussion describing the issues to consider when cleaning the blanket and purchasing blanket washes but does not analyze the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. The issues discussed include: (1) optimization of the washing technique to reduce blanket wash use, press wipe use, and waste print runs; (2) derivation of blanket wash products from non-renewable (petroleum and natural gas) and renewable (plant products) chemical raw materials (it is not clear, however, which raw materials demand the least energy and natural resources without a full life-cycle analysis); (3) lack of differentiation between products in terms of energy consumption during the product formulation process because the same basic processes are used to formulate all blanket wash products; and (4) reduction in packaging requirements and transportation/distribution energy consumption due to the use of concentrated formulations, assuming the products are diluted by the printer. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

VOC Releases

The VOC content of the alternative and the baseline blanket washes was independently tested by the GATF laboratory in Pittsburgh, Pennsylvania. VOCs are currently regulated under clean air legislation occupational exposure rules and toxics use and release reporting laws; therefore, substitution of high VOC cleaners has the potential to reduce the regulatory burden for printers. Table I-3 presents a summary of the relative VOC content of the baseline and alternative blanket washes.

TABLE I-3: VOC CONTENT OF THE SUBSTITUTE AND BASELINE BLANKET WASHES

Blanket Wash	VOC Content (lbs/gal;% by weight)	Blanket Wash	VOC Content (% by weight)
Baseline (28)	6.2; 100%	22	Not measured; 2.17%
1	2.3; 30%	23	0.48; 6%
3	6.4; 91%	24	1.5; 19%
4	6.4; 89%	25	4.1; 55%
5	2.5; 30%	26	1.3; 18%
6	3.5; 47%	27	7.2; 93%
7	3.0; 36%	29	2.1; 30%
8	3.3; 41%	30	0.48; 7%
9	0.11; 10%	31	6.6; 99%
10	0.16; 2%	32	6.5; 99%
11	4.3; 61%	33	3.4; 46%
12	1.3; 20%	34	2.8; 39%
14	0.97; 12%	35	6.7; 99%
16	7.2; 99%	36	3.5; 48%
17	0.051; 0.6%	37	1.0; 14%
18	4.4; 60%	38	4.9; 65%
19	1.8; 22%	39	2.9; 37%
20	2.7; 35%	40	3.8; 52%
21	3.5; 47%		

Performance

The performance of each of the substitute blanket washes as well as the baseline was demonstrated using both laboratory and production run tests. The laboratory tests determined the flash point, VOC content, and pH and demonstrated the blanket swell and wipability of each product. The production run tests, conducted at two facilities for each of the substitute products and at all facilities for the baseline, collected information such as quantity of wash used, time spent to wash the blanket, ink coverage, and the effectiveness of the wash. Summary results are presented in Table I-4. The widely variable conditions between and within printing facilities and the short duration of the production runs used for the performance demonstrations does not allow the results to be interpreted as definitive performance assessments of the blanket washes.

Prior to testing the blanket washes in a print shop, the 36 substitute blanket washes were tested in the laboratory for blanket swell potential and wipability. Of the 36 washes, 22 were deemed to be satisfactory for demonstrations at volunteer printing shops (two shops demonstrated each blanket wash). The results of the performance demonstrations were highly variable between the two print shops using a particular blanket wash and among the many blanket washes themselves. Performance varied to a great extent based on the amount of ink coverage. Excluding trials with heavy ink coverage, 11 washes gave good or fair performances at both facilities, 7 washes gave good or fair performance at one facility but not the other, and the remaining 4 washes performed poorly at both facilities.

Labor, Materials, and Product Costs

The costs of using each of the substitute blanket washes as well as the baseline depends on variations in labor costs, product use, and material and equipment use at each facility that participated in the performance demonstrations. Each substitute blanket wash product was tested by two facilities. The baseline product was tested by all facilities. Costs for each product are presented on a per wash basis, a per press basis, and a cost per press/shift/year basis. In comparing the cost data for the substitute and the baseline products, the costs of using the substitute blanket cleaners exceed the cost of using the baseline product in nearly all cases. In some cases smaller quantities of wash or less cleaning time was required, resulting in a cost savings when using the substitute instead of the baseline wash. (Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs associated with using the substitute blanket washes range from a low of \$1.72 to a high of \$8.80 per press.² Costs of using the baseline product range from \$1.64 to \$3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from 1 percent to 179 percent.) Table I-5 presents a summary of the cost comparisons.

Disposal costs were not considered in this cost comparison because all but one of the printers participating in the performance demonstrations use cloth wipes that are leased from an industrial laundry. Many industrial laundries currently do not distinguish between hazardous and nonhazardous blanket washes when laundering wipes; therefore, it was assumed that there would be no savings in waste handling or processing costs associated with switching to a substitute blanket wash product.

² Presses are assumed to have four units; therefore, four blankets are washed each time a press is cleaned.

Introduction to Social Benefit/Cost Assessment

Social benefit/cost analysis is a tool used by policy makers to systematically evaluate the impacts to all of *society* resulting from individual decisions. The decision evaluated in this analysis is the choice of a blanket wash product. Printers have certain criteria which they use to evaluate the benefits and costs of alternative blanket cleaners such as price, drying time, flexibility of use for rollers and blankets, propensity to cause blanket swell, etc. A printer might ask what impact their choice of blanket washes will have on operating costs, compliance costs, liability costs, and insurance premiums. This business planning process is unlike social benefit/cost analysis, however, because it approaches the comparison from the standpoint of the individual printing firm and not from the standpoint of *society*. A social benefit/cost analysis seeks to compare the benefits and costs of a given action, considering both the private and external costs and benefits.³ Therefore, the analysis will consider the impact of the alternative blanket cleaners on operating costs, regulatory costs, and insurance premiums, but will also consider the *external* costs and benefits of the alternative blanket cleaners such as reductions in environmental damage and reductions in the risk of illness for the general public. External costs are not borne by the printer, however; they are true costs to society.

Benefits of the substitute blanket cleaners may include private benefits such as increased profits resulting from improved worker productivity, a reduction in employee sickness, or reduced property and health insurance costs and external benefits such as a reduction in pollutants emitted to the environment or reduced use of natural resources. Costs of the substitute blanket cleaners may include private costs such as higher operating expenses resulting from a higher priced blanket wash and external costs such as increase in human health risks and ecological damage. Several of the benefit categories considered in this analysis share elements of both private and external costs and benefits. For example, use of the substitute blanket washes may result in energy and natural resource savings. Such a benefit may result in private benefits in the form of reduced product usage and waste print runs as well as external benefits in the form of reduced consumption of non-renewable resources.

Benefit/Cost Methodology

The methodology for conducting a social benefit/cost assessment can be broken down into four general steps: (1) obtain information on the relative performance, human and environmental risk, process safety hazards, and energy and natural resource requirements of the

³ Private costs include any direct costs incurred by the decision maker and are typically reflected in the firm's balance sheet. In contrast, external costs are incurred by parties other than the primary participants to the transaction. Economists distinguish between private and external costs because each will affect the decision maker differently. Although external costs are real costs to some members of society, they are not incurred by the decision maker and firms do not normally take them into account when making their decisions. A common example of external costs is the electric utility whose emissions are reducing crop yields for the farmer operating downwind. The external costs incurred by the farmer in the form of reduced crop yields are not considered by the utility when deciding how much electricity to produce. The farmer's losses do not appear on the utility's balance sheet.

APPENDIX I

baseline and the alternatives; (2) construct matrices of the data collected; (3) when possible, monetize the values presented within the matrices; and (4) compare the data generated for the alternative and the baseline in order to produce an estimate of net social benefits. The Findings section presents the results of the first task by summarizing the performance data, risk data, and energy and natural resource information for the baseline and the alternative blanket washes. In Table I-5 the data required to make a determination of the relative costs and benefits of switching to an alternative blanket wash are organized according to formulation number, beginning with the baseline. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products, allowing identification of the substitute product whose use results in the largest net social benefits. However, because of data limitations and production facility variations, the analysis presents instead a qualitative description of the risks associated with each substitute product compared to the baseline. Benefits derived from a reduction in risk are described and discussed, but not quantified; the information provided can be very useful in the decision making process. A few examples are provided to quantitatively illustrate some of the benefit considerations. Personnel in each individual facility will have to examine the information presented, weight each piece according to facility and community characteristics, and develop an independent choice.

The analysis is further developed in the following sections, beginning with summaries of the potential risks of the substitute and baseline blanket washes. Associated Costs provides a summary of the financial costs of the baseline and the alternative blanket washes, Costs and Benefits by Formulation compares the benefits and costs of using the substitute blanket wash products instead of the baseline wash, and Potential Benefit of Avoiding Illness Linked to Exposure to Chemicals Commonly Used in Blanket Washing provides an indication of the minimum benefits per affected person that would accrue to society if switching to substitute blanket wash products reduced cases of certain adverse health effects.

TABLE I-6: COSTS AND BENEFITS OF BASELINE AND SUBSTITUTE BLANKET WASHES						
Formula Number	Private Cost ^a		Private Benefits			External Benefits
	Average Cost/Press	% Change	Worker Risk Trade-offs	Flammability Risk ^b	% VOC	Environmental Risk
Baseline (28)			Low to moderate concern for dermal and inhalation exposure. ^d	High risk	99%	No estimated risk
1	Alternative: 2.76 Baseline: 2.20	+25	Overall concern is low for dermal and inhalation exposure. ^d	Low risk	30%	No estimated risk
	Alternative: 3.48 Baseline: 2.20	+89				
3	Not tested		Concern for dermal exposure and inhalation.	Moderate risk	91%	Aquatic species risk
4	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	89%	No estimated risk
5	Not tested		Concern for dermal exposure and very low concern for inhalation exposure.	Moderate Risk	30%	Aquatic species risk

DATA SUMMARY AND SOCIAL BENEFITS/COSTS ASSESSMENT

TABLE I-6: COSTS AND BENEFITS OF BASELINE AND SUBSTITUTE BLANKET WASHES							
6	Alternative:	3.28	+17	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	47%	Aquatic species risk
	Baseline:	2.80					
	Alternative:	3.08	+54				
	Baseline:	2.00					
7	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	36%	No estimated risk
8	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	41%	Aquatic species risk
9	Alternative:	8.32	+129	Very low concern for dermal exposure and no concern for inhalation exposure. ^d	Low risk	10%	No estimated risk
	Baseline:	3.64					
	Alternative:	3.68	+84				
	Baseline:	2.00					
10	Alternative:	2.28	+4	Very low concern for dermal exposure ^c and no concern for inhalation exposure. ^d	Low risk	2%	No estimated risk
	Baseline:	8.80					
	Alternative:	8.80	+159				
	Baseline:	3.40					
11	Alternative:	5.16	+119	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	61%	Aquatic species risk
	Baseline:	2.36					
	Alternative:	2.72	+28				
	Baseline:	2.12					
12	Alternative:	3.96	+22	Concern for dermal exposure and low concern for inhalation exposure. ^c	Moderate risk	20%	No estimated risk
	Baseline:	3.20					
	Alternative:	3.32	+4				
	Baseline:	3.20					
14	Alternative:	4.28	+133	Low concern for dermal and inhalation exposure. ^c	Low risk	12%	No estimated risk
	Baseline:	1.84					
	Alternative:	3.28	+24				
	Baseline:	2.64					
16	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	99%	No estimated risk
17	Not tested			Possible concern for dermal exposure and very low concern for inhalation exposure. ^d	Low risk	0.6%	No estimated risk
19	Alternative:	6.64	+168	Low concern for dermal and inhalation exposure. ^c	Low risk	22%	No estimated risk
	Baseline:	2.48					
	Alternative:	3.56	+68				
	Baseline:	2.12					
20	Alternative:	4.52	+61	Concern for dermal exposure and low concern for inhalation exposure. ^c	Low risk	35%	Aquatic species risk
	Baseline:	2.80					
	Alternative:	6.32	+95				
	Baseline:	3.24					
21	Alternative:	4.04	+120	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	47%	No estimated risk
	Baseline:	1.84					
	Alternative:	2.32	+41				
	Baseline:	1.64					

APPENDIX I

TABLE I-6: COSTS AND BENEFITS OF BASELINE AND SUBSTITUTE BLANKET WASHES							
22	Alternative:	3.28	+1	Moderate concern for dermal exposure ^c and low concern for inhalation exposure. ^d	Low risk	17%	No estimated risk
	Baseline:	3.24					
	Alternative:	6.04	+89				
	Baseline:	3.20					
23	Not tested			Possible concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	6%	No estimated risk
24	Alternative:	3.88	+47	Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	19%	No estimated risk
	Baseline:	2.64					
	Alternative:	3.52	+115				
	Baseline:	1.64					
25	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	55%	No estimated risk
26	Alternative:	2.92	+33	Concern for dermal exposure and no concern for inhalation exposure. ^d	Low risk	18%	No estimated risk
	Baseline:	2.20					
	Alternative:	1.88	-6				
	Baseline:	2.00					
27	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	93%	No estimated risk
29	Alternative:	3.72	+63	Low concern for dermal exposure ^c and no concern for inhalation exposure. ^d	Low risk	30%	No estimated risk
	Baseline:	2.28					
	Alternative:	3.56	+62				
	Baseline:	2.20					
30	Alternative:	4.04	+63	Concern for dermal exposure and low concern for inhalation exposure. ^c	Moderate risk	7%	No estimated risk
	Baseline	2.48					
	Alternative:	2.48	+17				
	Baseline:	2.12					
31	Alternative:	6.36	+179	Concern for dermal exposure and low concern for inhalation exposure. ^c	Moderate risk	99%	No estimated risk
	Baseline:	2.28					
	Alternative	2.36	+7				
	Baseline:	2.20					
32	Alternative:	5.24	+122	Low to moderate concern for dermal and inhalation exposure. ^c	Low risk	99%	No estimated risk
	Baseline:	2.36					
	Alternative:	1.72	-19				
	Baseline:	2.12					
33	Not tested			Concern for dermal exposure and very low concern for inhalation exposure.	Moderate risk	46%	No estimated risk

TABLE I-6: COSTS AND BENEFITS OF BASELINE AND SUBSTITUTE BLANKET WASHES							
34	Alternative:	3.56	+51	Concern for dermal exposure and low concern for inhalation exposure. ^c	Moderate risk	39%	No estimated risk
	Baseline:	2.36					
	Alternative:	3.80	+79				
	Baseline:	2.12					
35	Not tested			Concern for dermal exposure and low concern for inhalation exposure.	Moderate risk	99%	No estimated risk
36	Not tested			Concern for dermal exposure and low concern for inhalation exposure. ^c	Low risk	48%	No estimated risk
37	Alternative:	1.92	-13	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ^c	High risk	14%	No estimated risk
	Baseline:	2.20					
	Alternative:	3.16	-7				
	Baseline:	3.40					
38	Alternative:	4.32	+104	Low to moderate concern for dermal exposure and low concern for inhalation exposure. ^c	Low risk	65%	No estimated risk
	Baseline:	2.12					
	Alternative:	4.44	+31				
	Baseline:	3.40					
39	Alternative:	2.76	+25	Concern for dermal exposure and very low concern for inhalation exposure.	Low risk	52%	No estimated risk
	Baseline:	2.20					
	Alternative:	3.20	+45				
	Baseline:	2.20					
40	Alternative:	3.16	+34	Concern for dermal exposure and low concern for inhalation exposure. ^d	Low risk	52%	No estimated risk
	Baseline:	2.36					
	Alternative:	3.48	-4				
	Baseline:	3.64					

a) Cost analysis based upon product performance as determined by the performance demonstration at various testing facilities and pricing submitted by the product supplier. See Chapter 4 for a more in-depth description of the cost analysis and descriptions of the testing facilities.

b) Flammability risks are defined as follows: (1) High Risk: products with a flash point less than 100 °F; (2) Moderate Risk: products with a flash point greater than 100 °F but less than 150 °F; and (3) Low Risk: products with a flash point greater than 150 °F.

c) Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based upon a structure-activity analysis.

d) Risks for this chemical could not be quantified; therefore, the level of concern for this chemical is based solely upon estimated exposure levels.

Potential Benefits

The potential social benefits associated with the use of a substitute blanket cleaner versus the baseline wash include: reduced health risks for workers and the general public, reduced risk of fire and explosion due to lower flammability, reduced ecological risks, reduced use of energy and natural resources, and reduced VOC emissions. In order to assess the risk to workers, the EPA risk assessment combines hazard and exposure data for individual chemical components of the substitute as well as the baseline products into a single qualitative expression of risk. This qualitative expression of risk provides the basis for comparing the relative worker exposure risks associated with the use of the substitute blanket wash products as compared with the baseline. While members of the general public are also potentially at risk from blanket wash chemicals that

APPENDIX I

are released to air and water, the EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion. Due to data limitations, the exposure assessment does not estimate cumulative exposures from landfill releases or septic system releases. The relative risks of fire and explosion are determined by comparing the flash point of each blanket wash, using the OSHA definition of a flammable liquid as well as EPA's definition of an ignitable waste as a benchmark. In addition to the risks faced by workers and the general public, the risk assessment considers the potential ecological risks of using each of the alternative products and the baseline blanket wash. Several of the substitute formulations were found to present a risk to aquatic species. The energy and natural resource requirements of the substitute and the baseline blanket wash vary and a full life-cycle assessment, which was beyond the scope of this CTSA, would be needed to determine the requirements. The risks associated with VOC releases were not examined within the risk assessment; however, the relative VOC contents of the substitute formulations are discussed below since VOC releases are the primary driving factor behind current regulations affecting printers.

Reduced Worker Health Risks

Reduced risks to workers can be considered both a private and an external benefit. Private worker benefits include reductions in worker sick days and reductions in health insurance costs to the printer. External worker benefits include reductions in medical costs to workers as well as reductions in pain and suffering associated with work related illnesses. The EPA risk assessment considers two paths of worker exposure: inhalation and dermal. Inhalation exposure results from the volatilization of blanket wash chemicals from the blanket during washing and from the rags used to wipe down the blanket. Dermal exposure results from direct contact with the blanket wash chemicals during blanket cleaning. Worker dermal exposure to all products can be easily minimized by using proper protective equipment such as gloves or barrier creams during blanket cleaning. Worker health risks associated with the use of any blanket wash product are a function of both the product's toxicity as well as the degree of worker exposure which occurs during blanket cleaning. For example, the worker health risks associated with the use of a more toxic blanket wash may be reduced by the product's low volatility (i.e., reduced inhalation exposure) or workplace practices such as the use of automatic blanket cleaning technology (i.e., reduced dermal exposure). The exposure assessment estimates worker exposure (dermal and inhalation) for each of the blanket wash products. The risk assessment evaluates the toxicity of the individual blanket wash components for the substitute and baseline products and integrates the hazard and exposure information into a single qualitative expression of risk. The risk assessment does not provide a single measure of risk for the products overall, making it difficult in some cases to determine the relative risk from one product to another. For example, Blanket Wash 22 contains heavy aromatic solvent naphtha and fatty acid esters which were determined to possess moderate dermal concern and low dermal concern, respectively.

Reduced Public Health Risk

In addition to worker exposure, members of the general public may be exposed to blanket wash chemicals due to their close physical proximity to a printing facility or due to the wide dispersion of chemicals. Such releases impose an external cost on society that is typically not

considered by printing facilities in selecting their blanket wash. For example, people may breathe blanket wash vapors that have been released from a printing facility or people may drink water containing blanket wash residues discharged by a facility. Individuals in the general public that are exposed to blanket wash chemicals are therefore potentially subject to health risks. The EPA risk assessment identified no concerns for the general public through ambient air, drinking water, or fish ingestion. Using the model facility approach, the general population exposure assessment predicted that exposure levels would be extremely low for all media examined. Because of the low exposure levels, no concerns were identified for the general public from the use of blanket wash chemicals.

Reduced Flammability Risk

Some blanket wash chemicals in this assessment present risks of fire and explosion because of their flammability and high volatility (Tables I-2 and I-3). Reduced flammability risk may result in both private and external benefits. Private benefits may accrue to the printer in the form of lower risk of fire damage to the print shop. The population surrounding the print shop may experience external benefits in the form of lower risks of fire damage to their homes. In order to assess the relative fire hazard of the substitute and baseline blanket washes, the flash points of each product is compared to OSHA and EPA definitions of flammable liquids.⁴ Flammable liquids are defined by OSHA as having a flash point less than 141 °F. Similarly, EPA defines RCRA ignitable wastes (40 CFR 261.21) as having a flash point of 140 °F or less. The baseline product has a flash point of 50 °F, well below OSHA and EPA standards. Several of the substitute blanket washes have flash points below the OSHA and EPA thresholds: Blanket Washes 3, 4, 5, 8, 12, 21, 23, 24, 30, 31, 33, 34, 35, and 37.

Reduced Ecological Risk

Blanket wash formulations are potentially damaging to terrestrial and aquatic ecosystems, resulting in external costs borne by society. The EPA risk assessment evaluated the ecological risks of the substitute products as well as the baseline blanket wash; however, only the risks to aquatic species were considered. Reductions in aquatic species risks may create external benefits by increasing the catch per unit effort for commercial fishers as well as by increasing catch and participation rates of recreational fishers. The following formulations were found to pose a risk to aquatic species: Blanket Washes 3, 5, 6, 8, 11, 18, and 20. All the chemicals of concern are amine salts of an alkylbenzene sulfonate. Switching to these substitutes would likely increase aquatic risks rather than decrease them. The baseline product was not identified as creating an aquatic species risk.

Energy and Natural Resource Conservation

⁴ Flash point is defined as the lowest temperature at which a liquid gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid .

Benefits may accrue to society (external) as well as the printer (private) in the form of energy and natural resource savings if substitute blanket washes are substituted for the baseline wash. For example, Blanket Wash 34 was found to require fewer impressions to get back to acceptable print quality than with the baseline wash, thereby consuming less paper and energy. A similar situation may occur with press wipes. By switching to the substitute blanket wash, the printer might experience lower energy and resource costs. At the same time, society would also benefit from the printer's reduction in energy and natural resource use. However, the analysis of energy and resource conservation did not estimate the individual energy and natural resource requirements of the substitute and baseline washes due to various data limitations. A thorough quantitative evaluation of each life-cycle stage was beyond the scope of the CTSA.

Reduced VOC Releases

The reduction of VOCs within the pressroom can potentially result in private benefits including lower compliance costs and savings on insurance premiums, as well as external benefits including a safer work environment and reduced health effects outside of the facility.⁵ VOCs are currently regulated under clean air legislation as well as toxics use and release reporting laws and, therefore, were not re-evaluated as part of the risk assessment. Because there are several sources of VOCs within any given print shop, no attempt was made to quantify the benefits associated with an incremental reduction in the release of blanket wash VOCs. However, case studies are available documenting the potential benefits of VOC reduction throughout the pressroom. For example, the Commonwealth of Massachusetts Office of Technical Assistance found that Hampden Papers of Holyoke, Massachusetts experienced savings by reducing VOCs (97 percent reduction over a ten year period).⁶ Hampden Papers, by adopting a source reduction strategy, has avoided the need to purchase VOC collection and control equipment or explosion-proof mixers for inks and coatings containing VOCs. In addition, they have incurred significant savings in fire insurance premiums, and reduced their liability under Superfund, air regulations, OSHA, RCRA, and other laws (OTA, no date). VOC content of the baseline as well as the alternative formulations, as measured by the GATF laboratory, are presented in Table I-3. VOC content ranges from a low of 2 percent to a high of 99 percent. The baseline product and Blanket Wash 31 have the highest VOC content (99 percent).

Associated Costs

As discussed previously, in comparing the cost data for the alternative and the baseline

⁵ A successful VOC reduction strategy cannot be limited to blanket washes. All sources of VOC releases (i.e., inks, coatings, etc.) within the print shop must be evaluated in order to design and implement an efficient emissions control plan.

⁶ For a copy or further information about this case study, contact: Office of Technical Assistance (OTA), Executive Office of Environmental Affairs, 100 Cambridge Street, Boston, MA 02202, or phone OTA at (617) 727-3260.

products, the costs of using the alternative blanket cleaners exceed the cost of using the baseline product in nearly all cases. Some cases required smaller quantities of wash or less cleaning time, resulting in a cost savings when using the substitute instead of the baseline wash. (Blanket Washes 26, 32, 37, and 40 resulted in costs savings relative to the baseline product. Overall, however, the costs of using the substitute blanket washes exceed the costs of using the baseline wash in the large majority of cases. Costs of the using the substitute blanket washes range from a low of \$1.72 to a high of \$8.80 per press. Costs of using the baseline product range from \$1.64 to \$3.64 per press. Where costs of the alternative blanket washes exceed the baseline, percentage cost increases range from 1 percent to 179 percent.)

Costs and Benefits by Formulation

The objective of a social benefit/cost assessment is to identify those products or decisions that maximize net benefits. Ideally, the analysis would quantify the social benefits and costs of using the substitute and baseline blanket wash products in terms of a single comparable unit (i.e., dollars) and calculate the net benefits of using the substitute instead of the baseline product. Due to data limitations, however, the analysis presents a qualitative description of the risks associated with each product compared to the baseline. Table I-7 compares the relative risks and costs of each substitute blanket wash to the baseline. While this table presents a comparison between the blanket washes and the substitutes, it is important to keep in mind that not all of the risk assessments are based on risk (comprised of both exposure and hazard) but that some of the assessments are based solely on a hazard call based upon a structure-activity analysis. A frowning face (☹) indicates an increase in cost, worker health risks, flammability, risk to aquatic species, or VOC content when using the substitute blanket wash instead of the baseline product. A smiling face (☺) indicates a reduction in cost, worker risk, flammability, aquatic species risk, or VOC content when using the substitute instead of the baseline product. A zero (o) indicates that the risk assessment identified no difference in relative risks when using the substitute blanket cleaner instead of the baseline. Because the risk assessment evaluated individual blanket wash components, the relative worker health risks are based upon the component that poses the highest degree of concern. For example, components of Blanket Wash 32 were determined to pose no or low concern (propylene glycol ethers) and concern (aromatic and petroleum distillate hydrocarbons); therefore, the overall dermal risk of Blanket Wash 32 is one of concern. Blanket Wash 32 is shown to have similar relative dermal risks to workers when compared to the baseline because the baseline product's component of highest concern poses concern (i.e., petroleum distillate hydrocarbons).⁷

In nearly every case the substitute product costs more to use than the baseline. There were several products whose use was determined to decrease dermal worker health risks; these were Blanket Washes 1, 9, 10, 14, 17, 19, 22, 23, 29, 37 and 38. Formulation 10 was found to increase costs by less than 10 percent for one of the facilities. The few products that did show evidence of reduced costs, had mixed results in terms of their relative health risks. For example, Blanket Wash 37, which was found to be less expensive to use than the baseline, was found to

⁷ The risk classification scheme should be interpreted as follows: no/low concern < low to moderate concern < concern.

APPENDIX I

reduce worker dermal risks but was neutral in terms of relative inhalation risk. Blanket Washes 26 and 40 showed evidence of reduced costs; in addition, the risk assessment found that worker dermal risks were similar for both products over the baseline. In addition, while Blanket Wash 32 was less expensive than the baseline at one facility, it was found to present increased dermal and inhalation risks over the baseline. All of the substitute products had lower flash points and, therefore, reduced flammability risk when compared to the baseline. Finally, three Blanket Washes (6, 11, and 20) had higher aquatic risks than the baseline.

TABLE I-7: RELATIVE BENEFITS AND COSTS OF SUBSTITUTE VS BASELINE BLANKET WASH^a							
Formula Number	Cost/Press		Worker Health Risk		Flammability Risk	Risk to Aquatic Species	VOC Content^b
	Facility #1	Facility #2	Dermal	Inhalation			
1	☹	☹	☺	○ ^c	☺	○	☺
3	Not tested		○	☹	☺	☹	☺
4	Not tested		○	○	☺	○	☺
5	Not tested		○	○	☺	☹	☺
6	☹	☹	○	○	☺	☹	☺
7	Not tested		○	○	☺	○	☺
8	Not tested		○	○	☺	☹	☺
9	☹	☹	☹	○	☺	○	☺
10	☹	☹	☺ ^c	○	☺	○	☺
11	☹	☹	○	○	☺	☹	☺
12	☹	☹	○	○	☺	○	☺
14	☹	☹	☺ ^c	○	☺	○	☺
16	Not tested		○	○	☺	○	○
17	Not tested		☺	○	☺	○	☺
18	Not tested		○	○	☺	☹	☺
19	☹	☹	☺ ^c	○	☺	○	☺
20	☹	☹	○	○	☺	☹	☺
21	☹	☹	○	○	☺	○	☺
22	☹	☹	☺ ^c	○	☺	○	NM
23	Not tested		☺	○	☺	○	☺
24	☹	☹	○	○	☺	○	☺
25	Not tested		○	○	☺	○	☺
26	☹	☺	○	○	☺	○	☺
27	Not tested		○	○	☺	○	○

TABLE I-7: RELATIVE BENEFITS AND COSTS OF SUBSTITUTE VS BASELINE BLANKET WASH^a

29	☹	☹	☺	○	☺	○	☺
30	☹	☹	○	○	☺	○	☺
31	☹	☹	○	○	☺	○	○
32	☹	☺	☹	☹	☺	○	○
33	Not tested		○	○	☺	○	☺
34	☹	☹	○	○	☺	○	☺
35	Not tested		○	○	☺	○	○
36	Not tested		○	○	☺	○	☺
37	☺	☺	○	○	☺	○	☺
38	☹	☹	☺	○	☺	○	☺
39	☹	☹	☺	○	☺	○	☺
40	☹	☺	○	○	☺	○	☺

Potential Benefit of Avoiding Illness Linked to Exposure to Chemicals Commonly Used in Blanket Washing

As mentioned above, the risk assessment did not link exposures of concern to adverse health outcomes. Data do exist, however, on the cost of avoiding or mitigating certain illnesses that are linked to exposures to blanket wash chemicals. Such cost estimates indicate potential benefits associated with switching to less toxic products. Health endpoints potentially associated with blanket wash chemicals include: eye irritation, headaches, nausea, and asthma attacks. The following discussion presents estimates of the economic costs associated with each illness. To the extent that blanket wash chemicals are not the only factor contributing toward the illnesses described, individual costs may overestimate the potential benefits to society from substituting alternative blanket cleaners; also, this is not a comprehensive list of the potential health effects of exposure to blanket washes. For instance, inks and other pressroom chemicals may also contribute toward adverse worker health effects. The following discussion focuses on the external benefits of reductions in illness: reductions in worker medical costs as well as reductions in pain and suffering related to worker illness. However, private benefits, accrued by the decision-maker, may be incurred through increased worker productivity and a reduction in liability and health care insurance costs. While reductions in insurance premiums as a result of pollution prevention are not currently widespread, the opportunity exists for changes in the future.

Often adverse health effects are experienced when working with chemicals. For example, press operators at facility 12 experienced nausea and dizziness when using Blanket Wash 20, a petroleum based blanket wash containing petroleum distillates and aromatic hydrocarbons. In addition, Blanket Wash 20 aggravated a previously existing respiratory condition in one press

APPENDIX I

operator. The economic literature provides estimates of the costs associated with eye irritation, headaches, nausea, and asthma attacks, each of which may result from exposure to blanket wash chemicals. An analysis summarizing the existing literature on the costs of illness estimates individual willingness-to-pay to avoid certain acute effects for one symptom day (Unsworth and Neumann, 1993). The estimates for eye irritation, headaches, nausea, and asthma attacks are all based upon a survey approach designed to illicit estimates of individual willingness-to-pay to avoid a given illness. Such surveys, when properly designed, should capture direct treatment costs, indirect costs, and costs associated with pain and suffering. As eye irritation, headaches, nausea, and asthma attacks typically occur as short-term, discrete incidents, cost estimates represent an individual's willingness-to-pay to avoid a single incidence and not the average lifetime cost of treating a disease. Table I-8 presents a summary of the low, mid-range, and high estimates of individual willingness-to-pay to avoid each of these health endpoints. These estimates provide an indication of the benefit per affected individual that would accrue to society if switching to a substitute blanket wash product reduced the incidence of eye irritation, headaches, nausea, and asthma attacks.

TABLE I-8: ESTIMATED WILLINGNESS-TO-PAY TO AVOID MORBIDITY EFFECTS FOR ONE SYMPTOM DAY (1995 DOLLARS)			
Health Endpoint	Low (\$)	Mid-Range (\$)	High (\$)
Eye Irritation ^a	20.79	20.79	46.14
Headache ^b	1.67	13.23	66.72
Nausea ^a	29.11	29.11	83.66
Asthma Attack ^c	15.62	42.96	71.16

a) Tolley, G.S., et al. January 1986. *Valuation of Reductions in Human Health Symptoms and Risks*. University of Chicago. Final Report for the U.S. EPA. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

b) Dickie, M., et al. September 1987. *Improving Accuracy and Reducing Costs of Environmental Benefit Assessments*. U.S. EPA, Washington, DC and Tolley, G.S., et al. *Valuation of Reductions in Human Health Symptoms and Risks*. January 1986. University of Chicago. Final Report for the U.S. EPA. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.

c) Rowe, R.D. and L.G. Chestnut. March 1985. *Oxidants and Asthmatics in Los Angeles: A Benefit Analysis*. Energy and Resource Consultants, Inc. Report to U.S. EPA, Office of Policy Analysis. EPA-230-07-85-010. Washington, DC. Addendum March 1986. As cited in Unsworth, Robert E. and James E. Neumann, Industrial Economics, Incorporated, Memorandum to Jim DeMocker, Office of Policy Analysis and Review, *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*. September 30, 1993.